Calculation Cover Sheet

Client:	**Columbia Water**
Project:	**30" Force Main Relocation Under I-20**
Project No:	10207730-20.2
Rev:	1
Calculation No:	Type Calc No. here
Page:	#. of #.
Title:	**Structural Design – TA10**

Purpose: Structural design of the end thrust restraint for the 30" pipe, for 150 psi (total). Thrust restraint sized based upon DIPRA Thrust Restraint Design Guide.

Originator:	M. Eric Martin	Date:	10/21/2024
Checked by:	Mike Baer, PE	Date:	10/22/2024
Approved by:		Date:	

Supersedes Calculation No:

Superseded by Calculation No:

Project:	CW Thrust Block	Computed:	RCM	Date:	8/13/24
Subject:		Checked:	MB	Date:	8/16/24
Task:	Concrete Block Design	Page:		of:	
Job #:	10207230-20.2	No:			

Design Pipe Thrust Block

- Design in-line thrust Restraint for 30" pipe for worst Case Dead-End.
- Pipe: 30" ϕ

  Area internal = $\frac{\pi}{4}(30)^2 = 707 in^2$
- Pressure: 50 psi (operating)

  100 psi (Surge) ← ULTIMATE

  150 psi

* For Construction case, only use operating pressure

* Total Thrust = $\frac{50(707)}{1000}$

$= 35.4\ k$

* Use DIPRA Thrust Restraint Design Guide to Design thrust Block

- Use Safety Factor of 1.5
- From Borings, most Soil in upper areas is Silt
  - Use 1500 psf for Allowable Bearing (See DIPRA)

Area Bearing = $\frac{SF(T)}{S_b} = \frac{1.5(35.4k)(1000\ \#/k)}{1500 psf}$

$= 35.4\ SF$

The following are general criteria for bearing block design.

- —Bearing surface should, where possible, be placed against undisturbed soil. Where it is not possible, the fill between the bearing surface and undisturbed soil must be compacted to at least 90% Standard Proctor density.
- —Block height (h) should be equal to or less than one-half the total depth to the bottom of the block, (H_t), but not less than the pipe diameter (D').
- —Block height (h) should be chosen such that the calculated block width (b) varies between one and two times the height.

TABLE 1
Horizontal Bearing Strengths

Soil	*Bearing Strength S_b (lb/ft²)
Muck	0
Soft Clay	1,000
Silt	1,500 ✓
Sandy Silt	3,000
Sand	4,000
Sandy Clay	6,000
Hard Clay	9,000

*Although the above bearing strength values have been used successfully in the design of thrust blocks and are considered to be conservative, their accuracy is totally dependent on accurate soil identification and evaluation. The ultimate responsibility for selecting the proper bearing strength of a particular soil type must rest with the design engineer.

The required bearing block area is

$$A_b = hb = \frac{S_f T}{S_b}$$ ✓

Then, for a horizontal bend,

$$b = \frac{S_f\, 2\, PA \sin(\varnothing/2)}{h\, S_b} \qquad (1)$$

where S_f is a safety factor (usually 1.5 for thrust block design). A similar approach may be used to design bearing blocks to resist the thrust forces at tees, dead ends, etc. Typical values for conservative horizontal bearing strengths of various soil types are listed in Table 1.

In lieu of the values for soil bearing strength shown in Table 1, a designer might choose to use calculated Rankine passive pressure (P_p) or other determination of soil bearing strength based on actual soil properties.

Gravity thrust blocks may be used to resist thrust at vertical down bends. In a gravity block, the weight of the block is the force providing equilibrium with the thrust force. The design problem is then to calculate the required volume of the thrust block of a known density. The vertical component of the thrust force in Figure 6 on page 8 is balanced by the weight of the block.

It can easily be shown that T_y=PA sin Ø. Then the required volume of the block is

$$V_g = \frac{S_f\, PA \sin\varnothing}{W_m} \qquad (2)$$

where W_m=density of the block material. Here, the horizontal component of the thrust force

$$T_x = PA\,(1-\cos\varnothing)$$

must be resisted by the bearing of the right side of the block against the soil. Analysis of this aspect will follow like the above section on bearing blocks.

Calculations of V_g and T_x for orientations other than when one leg is horizontal should reflect that specific geometry.

HDR

Project: CW Thrust Block	Computed: MLM	Date: 8/13/24
Subject:	Checked: MB	Date: 8/14/24
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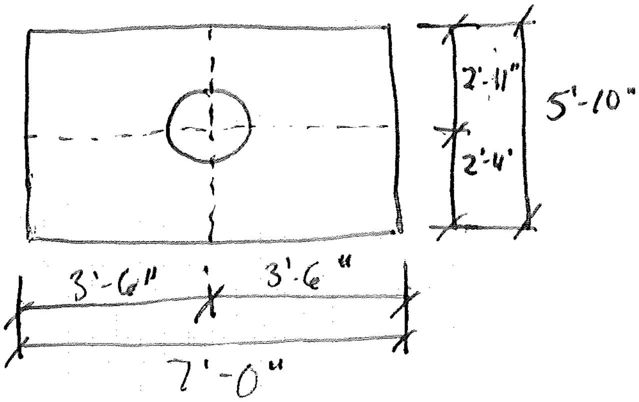
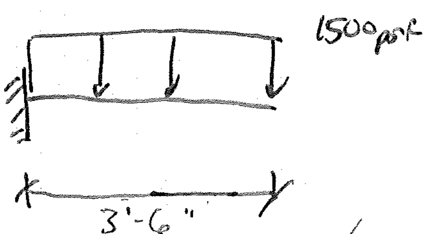
- A_B REQD = 106 SF



A = 40.8 ft²

- Check Bending in thrust Block, Primarily Bending in the 18'-6" Direction.

- Treat Block as cantilever about centerline



$M_u = \frac{1.6(1500)(3'\text{-}6")^2}{2} = 14.7$ k-ft/ft ✓

$V_u = 1.6(1500)(3.5') = 8.4$ k/ft ✓

- From Attached Spread Sheet, Use 28" Thick Thrust Restraint w/ #8 @ 8" O.C.

$\phi M_n = 124.4$ k-ft/ft $> M_u = 14.7$ k-ft/ft ✓

$\phi V_c = 24.2$ k/ft $> V_u = 8.4$ k/ft ✓

Basic Rebar Selection:

	WALL	Section Type (Beam, Wall or Slab)
fc'	3000 psi	Concrete Quality (range 1000 to 10000)
fy	60.0 ksi	Steel Quality (range 40 to 75)
β_1	0.85	Compression Block Factor
ϕ_{flex}	0.90	Strength Reduction Beam Flexure (ACI 9.3.2.1)
ϕ_{shear}	0.75	Strength Reduction Shear (ACI 9.3.2.3)

(Ref ACI 318-2002 C.3.2.3)

B	12.00 inch	Width of Section
H	28.00 inch	Depth of Section
d	24.500 inch	Depth of Reinforcing

☐ Warnings On.

Clear Cover	Stirrup Bar	d_b	Extra Fudge
3.00 inch	none	0.000 inch	0.000 inch

Num. Bars	Bar Size	d_b	A_s
1.50	8	1.000 inch	0.79

A_s	1.185	(in2 per width) Trial Area of Steel
Beam $A_{s,min}$	-	(in^2 per width) As minimum (ACI 10.5.1)
Slab $A_{s,min}$	-	(in2 per width) As minimum (ACI 7.12.2.1)
Wall $A_{s,min}$	0.504	(in2 per width) Vertical As minimum (ACI 14.3.2)
Wall $A_{s,min}$	0.840	(in2 per width) Horizontal As minimum (ACI 14.3.3)
ρ	0.0040	ratio of tension reinforcement
a	2.3235	Depth of equivalent stress block
M_n	138.28 k-ft	Moment Strength (nominal)
ϕM_n	124.45 k-ft	Moment Strength
V_c	32.21 kip	Concrete Shear Strength (nominal)
ϕV_c	24.15 kip	Shear Strength (ACI 11.3.1)

Minimum		
0.840	$A_{s,min}$	
0.0029	ρ_{min}	
1.6471	a	
99.44 k-ft	M_n	
89.50 k-ft	ϕM_n	
0.0214	0.75 $\rho_{balanced}$	okay

Vu	22.20 kip	
$\phi V_{s\ (req'd)}$	-1.95 kip	Min. Shear Reinforcing Required (ACI 11.5.5)
ϕV_s	0.00 kip	(ACI 11.5.6)
A_v	0.00	<== Assume (2) Leg Stirrup
s_{max}	0.00	
d/2	12.25	

$\phi V_{s\ (actual)}$ 0.00

Bar Size	A_s		
4	0.20	s_{actual}	12

Basic Formulas:

$$M_n = 0.85 f_c' b a \left(d - \frac{a}{2} \right) \qquad a = \frac{\rho \; d \; f_y}{0.85 \; f_c'}$$

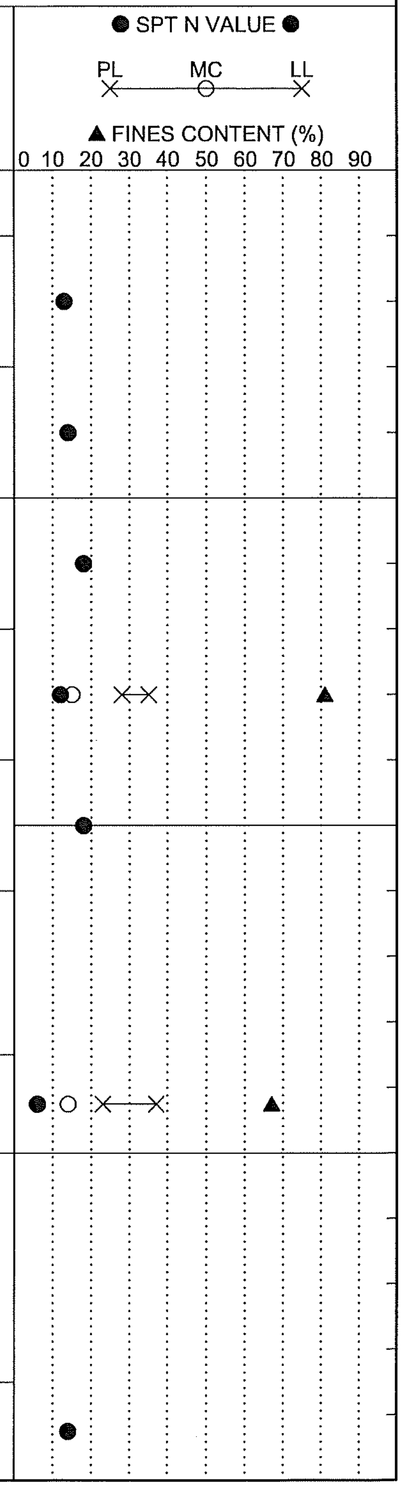
$$V_c = 2 \sqrt{f'_c} \, b \, d \qquad \rho = \frac{As}{bd}$$

$$V_s = \frac{A_v \; f_y \; d}{s}$$

SCDOT Soil Test Log

Project ID:	P027662		**County:**	Lexington/Richland	**Boring No.:**	B-50		
Site Description:	Carolina Crossroads I-20/26/126 Corridor Improvement Project				**Route:**	Site 44		
Eng./Geo.:	NGS	**Boring Location:**	91+54.21	**Offset:**	R:46.690'	**Alignment:**	Proposed	
Elev.:	212.6 ft	**Latitude:**	34.027285	**Longitude:**	-81.126258	**Date Started:**	2/18/2018	
Total Depth:	92.2 ft	**Soil Depth:**	72.2 ft	**Core Depth:**	20 ft	**Date Completed:**	2/18/2018	
Bore Hole Diameter (in):	3.5	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)	
Drill Machine:	CME 55	**Drill Method:**	RW	**Hammer Type:**	Automatic	**Energy Ratio:**	84.1%	
Core Size:	NQ	**Driller:**	T. Miller	**Groundwater:**	**TOB**	20.1 ft	**24HR**	38 ft

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	**SURFACE MATERIALS** - 12 inches of ASPHALT.							
	1.0	**FILL - SILTY SAND (SM)** - medium dense, moist, strong brown (7.5YR 5/8), mostly fine to medium sands, some low plasticity fines.	1.0	SS-1	10	5	8	7	13
	3.0	**SILT WITH SAND (ML)** - stiff, moist, light red (2.5YR 6/6) and reddish-yellow (7.5YR 6/6), mostly low plasticity fines, little fine sands.	3.0	SS-2	8	7	7	11	14
207.6		@ 5 feet - very stiff.	5.0	SS-3	5	9	9	6	18
		@ 7 feet - stiff, little fine to medium sands, [LL=35, PL=28, PI=7, NMC=14.5%, %#200=80.7], AASHTO = A-4 (6).	7.0	SS-4	4	6	6	8	12
202.6		@ 9 feet - very stiff.	9.0	SS-5	9	8	10	12	18
197.6	13.5	**SANDY LEAN CLAY (CL)** - firm, moist, yellowish-red (5YR 5/8), mostly low plasticity fines, little fine to medium sands, trace fine gravel, [LL=37, PL=23, PI=14, NMC=18.7%, %#200=67.3], AASHTO = A-6 (8).	13.5	SS-6	3	3	3		6
	18.5	**SANDY SILT (ML)** - stiff, moist, reddish-yellow (7.5YR 6/6), mostly low plasticity fines, little fine to medium sands, few quartz gravel.	18.5	SS-7	3	7	7		14



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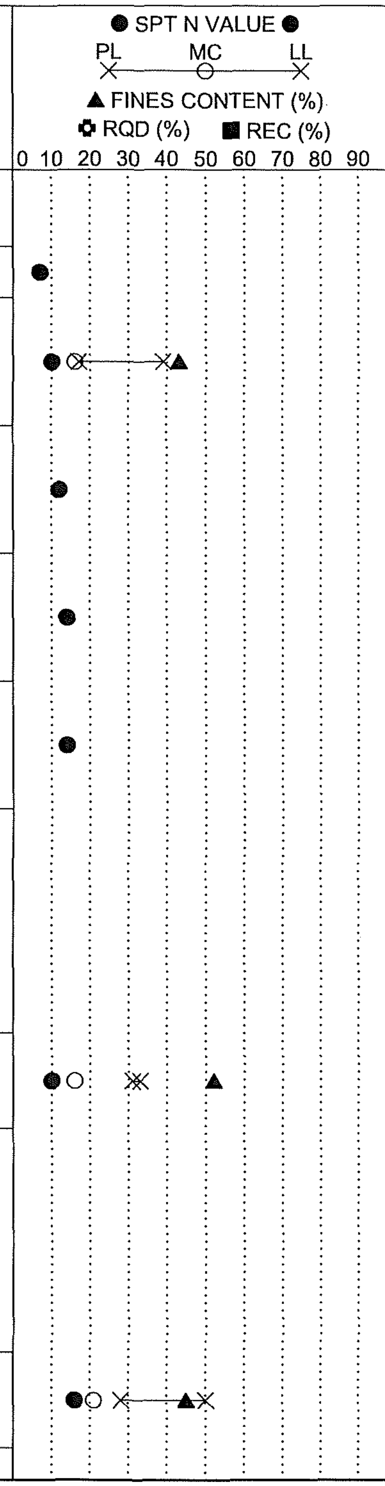
LEGEND

SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P039720	**County:**	Richland/Lexington	**Boring No.:**	C3C-U3
Site Description:	Carolina Crossroads I-20/26/126 Corridor Improvements			**Route:**	
Eng./Geo.:	C. Piercy	**Boring Location:**	100+46	**Offset:**	5-L
Alignment:	I-20 Median				
Elev.:	212.0 ft	**Latitude:**	34.02736797	**Longitude:**	-81.12640113
Date Started:	5/7/2024				
Total Depth:	59.9 ft	**Soil Depth:**	59.9 ft	**Core Depth:**	0 ft
Date Completed:	5/7/2024				
Bore Hole Diameter (in):	3	**Sampler Configuration**		**Liner Required:**	Y (N)
Liner Used:	Y (N)				
Drill Machine:	CME 550X	**Drill Method:**	RW	**Hammer Type:**	Automatic
Energy Ratio:	85.4%				
Core Size:	N/A	**Driller:**	L. Guempel	**Groundwater:**	TOB 13.5 ft
24HR	N/A				

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	ASPHALT ROADWAY (1.2-in.)							
	1.2	**EXISTING FILL** Loose to Medium Dense, Moist, Red, High Plasticity, Clayey Fine to Coarse SAND (SC/A-6), 2.5YR5/6	1.2	SS-1	3	7			7
		@SS-2: with Trace Gravel (Quartz) LL=39, PL=17, PI=22, NMC=15.8%, %200=42.8	2.0	SS-2	4	4	6	8	10
207.0		@2.9-ft.: Light Reddish Brown, 2.5YR6/4	4.0	SS-3	4	6	6	9	12
		@SS-4: Light Reddish Brown/Yellow, 2.5YR6/4 & 10YR7/8	6.0	SS-4	5	7	7	7	14
	8.0	@SS-5: No Recovery	8.0	SS-5	4	6	8	9	14
202.0									
	13.5 ▽	Stiff, Moist, Reddish Yellow, Low Plasticity, Sandy SILT (ML/A-4), with Trace Gravel (Quartz), 7.5YR7/6	13.5	SS-6	5	5	5		10
197.0		@SS-6: LL=33, PL=31, PI=2, NMC=15.5%, %200=52.2							
	18.5	Medium Dense, Moist, Light Red, High Plasticity, Clayey Fine to Coarse SAND (SC/A-7-6), with Trace Gravel (Quartz), 2.5Y6/6	18.5	SS-7	5	8	8		16
192.0									



LEGEND

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SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

HDR

Project: C W Thrust Block	Computed: MEM	Date: 10/21/24
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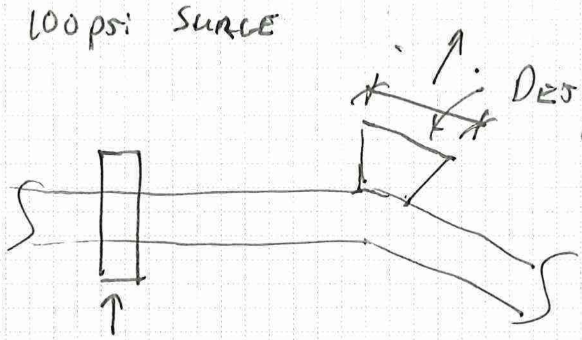
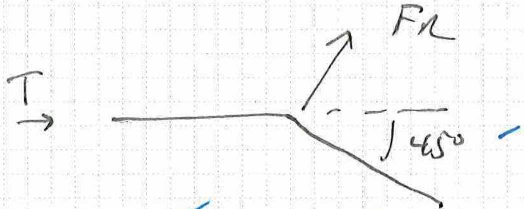
- Check Second Thrust Block @ BEND TO TAKE 100 psi SURGE



* NOTE THAT THRUST FROM SURGE IS CONSIDERED ULTIMATE ∴ SF = 1.0



T = 100psi (707 in²)
= 70.7k

$$b = \frac{SF \; 2PA \cdot \sin(\phi/2)}{h \; S_b}$$

h = 5'-0"

$$b = \frac{1.0\,(2)(70.7)\sin(45/2)}{5'\,(1.5\,ksf)}$$

b = 7.2 feet